

## FUEL ELEMENT

THIS INVENTION relates to solid fuel. More particularly, it relates to a solid fuel element and to a method of manufacturing a solid fuel element.

The invention extends to an accelerant composition for use in the manufacture of a solid fuel element.

The Applicant is aware of prior art in which a flammable liquid is incorporated into a charcoal briquette which is then coated with a coating. The Applicant believes that the present invention will dispense with the need for a coating to contain a volatile flammable liquid absorbed by a briquette within the briquette, by employing an evaporation inhibiting agent in combination with the liquid fuel/flammable liquid, thereby to inhibit evaporation of the liquid fuel absorbed into the briquette.

According to one aspect of the invention there is provided a solid fuel element, which includes a body of combustible material which is impregnated with an accelerant composition, including a liquid fuel and an evaporation inhibiting agent selected from thermoplastic elastomers, organic derivatives of clays, zirconium acetate and aluminium octanoate.

By accelerant composition is meant an inflammable

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composition which serves as a combustion aid or combustion promoter when the solid fuel element is ignited and when it burns.

As used herein, the term 'evaporation inhibiting agent' is to be understood to mean an agent that reduces the tendency of the fuel to evaporate, for example, by increasing its viscosity.

The body of combustible material may be a briquette made of a compressed combustible material. The compressed combustible material may be carbonaceous material, such as charcoal or coal dust. Preferably, the body will be a compressed charcoal briquette of the type used for outdoor cooking. Instead, the compressed combustible material may be cellulosic material, such as, for example, wood shavings. The body of combustible material may instead be of coal or solid charcoal.

The body may be sealed with a flammable sealant. More particularly, the body may be sealed with a flammable sealant in the form of a hydrocarbon wax composition, such as, for example, a paraffin wax/resin blend.

The sealant may at least partially be diffused through/permeate a surface of the body. Preferably, a major portion of the sealant is disposed beneath the surface of the body.

The liquid fuel may be a liquid paraffin. More particularly, the liquid fuel may be selected from  $C_9$  to  $C_{13}$  paraffins and mixtures of  $C_9$  to  $C_{13}$  paraffins.

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The evaporation inhibiting agent may be a thermoplastic elastomer.

The thermoplastic elastomer may be a rubber-styrene copolymer. More particularly, the rubber-styrene copolymer may be a copolymer of an olefinic rubber and styrene. The olefinic rubber may be selected from polyethylene/butylene and polyethylene/propylene. Preferably, the rubber-styrene copolymer includes at least 33 % by mass of styrene component. It may, for example, be the rubber-styrene copolymer available under the trade mark KRATON G Polymer from KRATON Polymers. The thermoplastic elastomer may form part of a blend comprising the thermoplastic elastomer and an oil, such as, for example, a mineral oil.

Instead, the evaporation inhibiting agent may be an organic derivative of a clay. More particularly, the evaporation inhibiting agent may be an organic derivative of a bentonite clay, such as that available under the trade mark BENTONE SD-1 or BENTONE 34 from Elementis Specialties. Naturally, however, any other suitable evaporation inhibiting agent, including zirconium acetate and/or aluminium octanoate, may be used.

According to another aspect of the invention, there is provided a solid fuel element which includes a body of combustible material having a seal of a flammable sealant, a major portion of which is disposed beneath the surface of the body.

The flammable sealant may be in the form of a hydrocarbon

wax composition. The hydrocarbon wax composition may be a paraffin wax/resin blend.

The seal may be of a hydrocarbon wax composition such as, for example, a paraffin wax/resin blend.

The body of combustible material may be as hereinbefore described.

According to yet another aspect of the invention, there is provided a method of making a solid fuel element, which method includes the step of at least partially immersing a body of combustible material in an accelerant composition, including a liquid fuel and an evaporation inhibiting agent selected from thermoplastic elastomers, organic derivatives of clays, zirconium acetate and aluminium octanoate, so that at least some of the accelerant composition is absorbed by the combustible material to produce an accelerant-impregnated body of combustible material.

The liquid fuel may be a liquid paraffin. More particularly, the liquid fuel may be selected from  $C_9$  to  $C_{13}$  paraffins and mixtures of  $C_9$  to  $C_{13}$  paraffins.

The evaporation inhibiting agent may be a thermoplastic elastomer, as hereinbefore described.

Instead, the evaporation inhibiting agent may be an organic derivative of a bentonite clay as hereinbefore described.

The body of combustible material may be solid charcoal or a briquette of compressed charcoal.

When the body of combustible material is a briquette of compressed charcoal, the method may include the prior step of compressing granular charcoal to form the briquette.

Instead, the body of combustible material may be a briquette of compressed cellulosic material, such as wood shavings, or of compressed granular coal, the method then including the prior step of compressing the cellulosic material or granular coal to form the briquette.

The method may include the step of subjecting the body of combustible material to reduced pressure prior to immersing the body in said accelerant composition. Instead, or in addition, the method may include subjecting the body of combustible material to a reduced pressure in the course of immersing the body in said accelerant composition. The body of combustible material may be subjected to a reduced pressure of between about 96 kPa and about 99 kPa, preferably between about 97 kPa and about 98 kPa. The method may include the step of subjecting the body of combustible material to increased pressure in the course of immersing the body in said accelerant composition. The body may be subjected to a pressure of between about 136 kPa and about 140 kPa, preferably between about 137 kPa and 138 kPa. Typically, the body is subjected to increased pressure following subjection to reduced pressure.

The body of combustible material may be at least partially

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immersed in the accelerant composition for a period of between about twenty seconds and about four minutes.

The method may further include sealing the accelerant-impregnated body of combustible material with a sealing material, thereby to seal the accelerant composition absorbed into the combustible material.

The sealing material may be a hydrocarbon material, such as, for example, a hydrocarbon/paraffin wax composition. Applying the sealing may then include at least partially immersing the accelerant-impregnated body of combustible material in a bath of molten hydrocarbon wax composition.

The accelerant-impregnated body of combustible material may be at least partially immersed in the bath of molten wax composition for a period of between about five seconds and about thirty seconds.

According to still another aspect of the invention, there is provided an accelerant composition which includes

an evaporation inhibiting agent selected from a thermoplastic elastomer, a thermoplastic elastomer/oil blend, an organic derivative of a clay, zirconium acetate and aluminium octanoate; and  
a liquid fuel.

The thermoplastic elastomer may be pre-blended with an oil, eg. a mineral oil, to form an oil gel.

The thermoplastic elastomer may be as hereinbefore described. More particularly, the thermoplastic elastomer may be a styrene block polymer, such as the elastomer available under the trade mark KRATON G Polymer from KRATON Polymers.

The organic derivative of a clay may be an organic derivative of a bentonite clay such as that available under the trade mark BENTONE SD-1 or BENTONE 34 from Elementis Specialties.

The liquid fuel may be a liquid paraffin. More particularly, the liquid fuel may be selected from  $C_9$  to  $C_{13}$  paraffins and mixtures of  $C_9$  to  $C_{13}$  paraffins.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings and Examples.

In the drawings

Figure 1 shows a sectional perspective view of a solid fuel element in accordance with the invention;

Figure 2 shows a schematic flow diagram depicting a method of making a solid fuel element in accordance with the invention; and

Figure 3 shows a schematic diagram of an installation for use in a method of making a solid fuel element in accordance with the invention.

In Figure 1 of the drawings, reference numeral 10 generally indicates a fuel element in accordance with the invention. The fuel element 10 includes a body 12 of compressed charcoal.

In other embodiments of the invention (not shown), the fuel element has a body of other combustible materials, such as solid charcoal, coal or a material comprised mainly of solid cellulosic material, eg wood shavings.

The body 12 is impregnated with an accelerant composition comprising a mixture of a liquid fuel and an evaporation inhibiting agent (not shown). In a preferred embodiment of the invention, the liquid fuel is a mixture of C<sub>9</sub> to C<sub>13</sub> liquid paraffins derived from coal. In one preferred embodiment, the evaporation inhibiting agent is the thermoplastic elastomer KRATON G Polymer (trade mark), a rubber-styrene copolymer available from KRATON Polymers. The KRATON G Polymer may form part of an oil gel blend comprising the polymer and a mineral oil. Instead, the liquid fuel may be mixed directly with the KRATON G Polymer, eg. by use of a static mixer or a high shear mixer. In another embodiment, the evaporation inhibiting agent is the organoclay, BENTONE SD-1 or BENTONE 34 (trade marks), both available from Elementis Specialties. In still other embodiments, the evaporation inhibiting agent is provided by zirconium acetate and/or aluminium octanoate. The evaporation inhibiting agent typically serves to increase the viscosity of the liquid fuel in the accelerant composition and to reduce the vapour pressure of the liquid fuel thereby to reduce evaporation of the liquid fuel. It will be appreciated that the accelerant composition tends to have a higher boiling point than that of the liquid fuel as a result of the presence of the evaporation inhibiting agent which has a high melting point. Typically, the accelerant composition is absorbed into a core 16 of the body 12.



The body 12 is sealed with a sealing of a flammable solid hydrocarbon wax composition shown at 14, typically, a paraffin wax/resin blend such as that available under the trade/product name EXP 1456 from Sasol Wax (South Africa) (Pty) Ltd. Typically, the bulk of the composition 14 penetrates the surface to a depth of between about 0,5 mm and about 1 mm, although the depth of penetration may vary from batch to batch of fuel elements 10.

#### EXAMPLE 1

The fuel element 10 was prepared by a continuous-feed process. Reference is made to Figure 2 of the drawings, which depicts the process diagrammatically and in which one tonne of briquettes was fed, via a dust extractor, onto a wire mesh conveyor at 30. The conveyor was passed over a vibrating table at 31 where the briquettes were sorted to assume flat orientations on the wire mesh conveyor. The briquettes were passed, on the conveyor, below the surface of a bath of accelerant composition at 32, and were submerged for about 3 minutes so that each briquette absorbed about 15 ml of accelerant composition. The accelerant composition here comprised a mixture of  $C_9$  -  $C_{13}$  liquid paraffins with KRATON G Polymer, the composition containing 3 % by mass KRATON G Polymer and the balance  $C_9$  -  $C_{13}$  liquid paraffins and having a melting point of about 100 °C. The bath was maintained at approximately the same temperature (i.e. 100° C) by means of a heat exchanger, through which the accelerant composition was circulated. Sensors, provided by thermocouples, were employed to sense the temperature of the bath and set a rate of circulation of accelerant composition through the heat exchanger thereby to maintain the bath at a

temperature of about 100 °C.

The briquettes were passed above the surface of the bath on the conveyor and transported over a drip-off area at 34, where drippings of accelerant composition were recovered for return to the bath at 32 for re-use. The briquettes were allowed to stand for about 5 seconds to allow their temperature to drop to just below 100 °C before being transported by the conveyor below the surface of a further bath of liquid EXP 1456 paraffin wax/resin blend, for about 5 seconds at 36. The briquettes were finally conveyed out of the bath and allowed to cool so that the wax composition solidified. In one embodiment (at 38) the briquettes were subjected to forced cooling to accelerate solidification of the wax composition. It is to be appreciated that because each briquette is at a temperature of just below 100 °C prior to immersion in the wax composition, the hot wax composition diffuses through the surface of the briquette and solidifies largely thereunder (see reference numeral 14 in Figure 1). The wax composition may in addition form a coating (not shown) on the surface. Typically between about 1 gram of paraffin wax/resin blend permeates the surface of the briquette.

Although the above describes a continuous-feed process, it is to be appreciated that, instead, a batching process may be used in making the fuel element 10 of the invention. In such a process, the briquettes would typically be placed in a vibratory basket. Dust collection would take place below the basket prior to submerging the basket in a bath of the accelerant composition. The basket of briquettes would then typically be raised and removed from the bath of accelerant composition and allowed to drip. To permit the contact of most, if not all, of the

briquettes in the basket with the accelerant composition, flow passages would typically be defined through the basket, for example, the basket may define an annular cavity for holding briquettes around a central flow passage. The basket containing the briquettes would then be dipped into a bath of hot paraffin wax/resin blend and removed and vibrated to remove excess wax. Typically the temperature of the briquettes during wax dipping will be greater than a solidification temperature of the wax blend such that the wax blend permeates the surface of the briquettes. Finally, the contents of the basket would be emptied out onto a conveyor and passed over a vibrating table.

## EXAMPLE 2

Reference is now made to Figure 3 of the drawings, in which reference numeral 50 refers generally to an installation for use in a method/process for making a fuel element 10 in accordance with the invention, and, unless otherwise indicated, the same reference numerals used above are used to designate similar parts.

The installation 50 includes an accelerant composition storage tank 52, for containing accelerant composition as hereinbefore described, and a sealant storage tank 54, for containing a paraffin wax/resin blend sealant as hereinbefore described. The installation 50 further includes a treatment vessel 56. Each of the storage tanks 52, 54 defines an outlet 58, 60 which is connected in flow communication, via a conduit 62, 64, respectively, defining a flow path, with a port 66 defined at an operatively lower end 68 of the treatment vessel 56. A valve 70, 72 is mounted in each of the flow paths 62, 64, proximate the port 66,

for controlling flow of accelerant composition and sealant into and from the treatment vessel 56 via the port 66.

Each of a vacuum pump 74 and a pressure pump 76 are connected in flow communication with the treatment vessel 56. Pressure valves 78, 80 are disposed between the vacuum pump 74 and the treatment vessel 56 and the pressure pump 76 and the treatment vessel 56, respectively.

In use, the accelerant composition is heated in the storage tank 52 to a temperature of 100 degrees Celsius by a heating element 82 mounted in the vessel 52. Similarly, the sealant is heated to a temperature of 150 degrees Celsius by a heating element 84 mounted in the vessel 54. Both the accelerant composition and the sealant are agitated in their respective vessels 52, 54 to promote even temperature distribution.

Briquettes 100 are loaded into a basket 90 comprising a metal framework and wire mesh side walls (not shown) and the basket 90 is inserted into the treatment vessel 56. Typically, operatively upright helical rods 92 are mounted in the basket 90, surfaces thereof providing a fluid flow path between the briquettes 100 received in the basket 90.

Once the briquettes 100 are loaded within the basket 90 into the treatment vessel 56, the vessel 56 is sealed fluid-tight and the valve 78 opened. A vacuum is induced within the treatment vessel 56 by the vacuum pump 74. Typically sub-atmospheric pressure of between 97 kPa and 98 kPa is induced in the treatment vessel 56. It will be

appreciated that the vacuum serves to exhaust air from interstices defined in the briquettes 100 between particles of the compressed material of which they are comprised. The vacuum is typically maintained for about one minute prior to opening the valve 70. The vacuum is maintained whilst the valve 70 is opened and accelerant composition is drawn from the storage tank 52, via the port 66, into the treatment vessel 56, rising until it covers the briquettes 100 held within the basket 90. The valve 70 is closed once the briquettes 100 are completely submerged and the briquettes 100 are held in the accelerant composition under the vacuum conditions of 97 kPa to 98 kPa for about thirty seconds. The valve 78 is then closed and the valve 80 opened and the vessel 56 is now subjected to a pressure above atmospheric pressure of between 137 kPa and 138 kPa. The vacuum is thus released whilst the briquettes 100 are submerged in the accelerant composition. As the pressure equalises, accelerant composition is drawn into the briquettes 100 and continues to migrate into the briquettes 100 as the vessel 56 is pressurised to 137 kPa to 138 kPa. This pressure is maintained for about one minute, whereafter the valve 70 is opened so that accelerant composition can drain from the vessel 56 via the port 66. It will be appreciated that the applied pressure facilitates expulsion of accelerant composition from the vessel 56. Typically, the basket 90 is vibrated during draining of the accelerant composition from the vessel 56 to facilitate removal of excess accelerant composition from the briquettes 100/basket 90. To this end, in one embodiment, the installation 50 includes a pneumatic vibrator 94 coupled to the pressure pump 76, a valve 96 being mounted in line between the pressure pump 76 and the vibrator 94 selectively to activate and deactivate the pneumatic vibrator 94.

Once all excess accelerant composition has been drained from the treatment vessel 56, the valves 70 and 80 are closed sequentially and the pneumatic vibrator 94 is deactivated by closing the valve 96.

The valve 78 is then opened once more and a vacuum drawn. At the same time, the valve 72 is opened and wax sealant is drawn from the tank 54 into the treatment vessel 56 via the port 66 and rises within the vessel 56 until the briquettes 100 are covered. When the briquettes 100 are fully covered, the valves 72, 78 are closed sequentially and the briquettes 100 are held in the wax composition for about twenty seconds so that the wax composition migrates beneath the surfaces of the briquettes 100. It is to be appreciated that the briquettes 100 are typically maintained at a temperature above the solidification temperature of the wax composition so that the wax composition migrates beneath the surfaces of the briquettes 100 and solidifies thereunder to provide a subsurface sealing layer 14.

Excess wax is thereafter evacuated under pressure from the vessel 56 by opening the valve 72 and the valve 80. The pneumatic vibrator 94 is typically activated to agitate the basket 90 thereby to remove excess wax from the basket 90 and briquettes 100 therein. The valves 72, 80 and 96 are sequentially closed when all excess wax has been evacuated.

The briquettes 100, having been impregnated with accelerant composition and sealed with a subsurface wax/resin blend to

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yield fuel elements 10 of the invention, are removed from the vessel 56 and cooled to ambient temperature prior to packaging thereof.

The Applicant believes that the vacuum applied prior to submersing the briquettes 100 in accelerant composition in the abovedescribed method facilitates absorption of the viscous accelerant composition into the briquettes 100 by expelling air from interstices in the briquettes 100. Further, the pressure applied to the briquettes 100 whilst submerged in the accelerant composition enhances absorption of accelerant composition, such that a saturated briquette 100 can be yielded.

It is an advantage of the fuel elements 10 of the invention that evaporation of the liquid fuel component of the accelerant composition is inhibited by the evaporation inhibiting agent of the composition such that the liquid fuel is retained within the fuel elements 10. Accordingly, even upon breaking of a fuel element 10 of the invention, the liquid fuel will be retained within the pieces of broken fuel element 10, evaporation thereof being inhibited by the evaporation reducing agent.

Further, it will be appreciated that the waxy sealant 14 imparts a waterproof property to the fuel element 10. Moreover, the sealant 14 serves to seal the accelerant composition in the body 12. It is an advantage of the present invention that the sealant is largely disposed beneath the surface of the fuel element 10 as the sealant is not susceptible to chipping off in as much as a surface coating would be.

The Applicant believes that the fuel element 10 of the invention will provide a self-lighting and combustible fuel element 10, dispensing with the need to employ fire lighters, which can be costly and ineffective, in igniting briquettes. It has been found that the fuel element 10 is capable of ignition typically by use of a single match and yields a smouldering coal, in which the flame has burnt out within a short period of about 10 minutes. This in turn lends the fuel element 10 to use in preparing a fire suited to barbecuing within a relatively shorter time span of about 20 minutes than is the case with conventional briquettes. The Applicant believes that fuel elements 10 of the invention will provide an inexpensive and effective means for generating an even bed of coals and will afford sustainable burning. Further, the fuel elements 10 permit of handling thereof without associated fouling or soiling of the hands of a user as is the case with conventional briquettes/coal.

The Applicant believes that the invention would function better in outdoor, humid and rainy conditions than conventional briquettes due to its waterproof characteristics.

It is also an advantage that the fuel element 10 of the invention is more suitable for use in a semi-enclosed cooking area such as a patio than conventional briquettes as the fuel element 10 of the invention is clean burning, being virtually smokeless due to the accelerant composition's ability to ignite the body of combustible material completely. This in turn, it is believed, will offer the advantage that each fuel element 10 burns completely, making for even heat and the use of fewer briquettes. Further, no toxic fumes are emitted during burning of the fuel element 10. Both the accelerant composition and wax/resin



sealant of the fuel element 10 of the invention are suited to use as ingredients in articles intended for food contact, such that the fuel elements 10 are suited for use in cooking, more particularly, barbecuing food. The accelerant composition is virtually odorless.

The Applicant believes that the fuel elements 10 of the invention, with their protective sealant, will have an extended shelf life and be resistant to damage, resulting in fewer broken briquettes. The Applicant believes that the materials used in the fuel elements 10 will not be hazardous for transport.